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HISTORICAL SKETCH OF POWDER METALLURGY

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In Polish technical literature, besides the term "powder metallurgy," the terms "ceramics of metals," "metallurgical ceramics," or "ceramics of powders" have been applied. The last two terms appear only sporadically.

The first note on the technology of "metal ceramics" appearing in Polish technical literature was in an article in 1934 in the Przeglad Techniczny (Technical Review), by Prof Dr Wlodzimierz Trzebiatowski, entitled "On Metal Ceramics; Their Application in Industry." The author discussed the technology of powder metallurgy and its advantages and applications. Trzebiatowski, proceeding in the footsteps of his teacher, has also used the name "metal ceramics" in an article entitled "Hard Alloys" which appeared in Zycie Techniczne (Technical Life) for 1939 and after the war in the 1946 booklet entitled Metal Ceramics. The name "ceramics of metals" was used together and interchangeably with "powder metallurgy" during 1947 - 1948 by the workers in the Institute of Metallurgy at Gliwice.

The term "powder metallurgy" was first used in technical literature in 1934. W. P. Sykes, an American specialist in the field of tungsten and sintered carbides used the term "powder metallurgy" for the first time in an article which appeared in Metal Progress in 1934. This name was quickly accepted in the Anglo-Saxon world, even though the term "metal ceramics" is not encountered until 1938.

In 1936, the Soviet periodical Vestnik Metallopromyshlennosti (Messenger of the Metal Industry) carried articles by M. Yu. Bal'shin. M. Yu. Bal'shin is one of the leading powder metallurgists in the world. Bal'shin used the term "metal-ceramics" in his writings and his 1938 book carries the same title. This term was used in Soviet technical literature until 1948, when he wrote the book entitled Poroshkovoye Metallovedeniye (Knowledge of Powder Metals). B. A. Borek and J. J. Olhov, in the book entitled Poroshkovaya Metallurgia (Powder Metallurgy) appearing in the middle of 1948, discarded the term "metal-ceramics" since it did not adequately cover the problem.

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In 1922, Schroter, from the Osram Company (therefore, an employee of an electrotechnical firm) added a cobalt to carbides. Krupp improved this method and produced his "Vidia" in 1927.

About 1930, an important development took place in the industry making sintered self-lubricating bearings from porous bronze. Later, the cheaper and stronger sintered porous iron was substituted for porous bronze. Porous iron and a combination of iron with graphite and lead in the form of sintered bearings began to be applied more or less from 1935.

The development of the hard magnetic materials or sintered magnetos began in 1934 for the electrical industry. Besides cast and hammered magnetos, sintered ones are used. Sintered magnetos of small dimension (weighing from 30 to 60 grams) are superior in certain respects to cast magnetos.

In 1927, a few years before the appearance of sintered magnetos, Polydorov applied pressed iron cores to high-frequency circuits. These cores were improved on during later years by the application of special types of pure iron, iron-nickel alloy, and other powders.

Although Polish industry has not contributed anything to the development of powder metallurgy, the three basic scientific treatises by Prof Dr Wl. Trzebiatowski which appeared abroad in 1934 enriched theory and brought fame to this scientist and to Polish science.

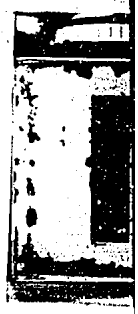
The mass production of sintered parts from iron and steel powders, and to a lesser extent from the powders of bronze, brass, copper, and light metals, belongs to the most modern achievements of powder metallurgy. It is true that sintered shapes were produced from iron and steel before the war, during the years 1935 to 1939, but only on a small scale. Only during World War II were they applied at a rate of over 100,000 tons annually. Factors hastening the development of this branch of powder metallurgy were the lack of manpower for machining complicated parts of machines and weapons, difficulties with casting, and scarcity of materials.

For high-vacuum purposes, for the construction of radio tubes, electric bulbs, rectifiers, and for experiments in physics, metals and alloys are required which have special physical properties such as an accurately defined coefficient of expansion, chemical purity, electric and heat-conductivity, etc. For this purpose, sintered nickel and sintered alloys of iron-chromium or iron-nickel-cobalt were applied.

An important application of powder metallurgy is in the production of sintered diamond-metallic tools for grinding or polishing. One of the main reasons for the development of these materials was the difficulty in precision grinding and in polishing tools made from sintered carbides.

During the war, both fighting sides worked on the problem of sintered alloys that would be heat resistant and that would have good mechanical properties at higher temperatures. The builders of jet engines set high demands. Apart from alloys of varying composition with high cobalt content, ceramic materials (like Al_2O_3), metal borides and carbides, and nonmetallic compounds were combined with pure metals. One of the youngest branches of powder metallurgy (since 1939) comprises the production of friction materials for clutches and brakes. Friction sinterings consist mainly of copper with small additions of tin, lead, iron graphite, silex, oxide, and aluminum.

For such sintered products as metals with a high melting point, sintered carbides, porous bearings, ceramic-metals, and combined metals, there is no technological method other than powder metallurgy. Other products, for example,



sintered shapes from iron, steel, bronze, brass, and other metals and alloys, for high-vacuum purposes, can also be obtained and given special physical properties by casting or machining. Wherever powder metallurgy has been applied, it has been only for the following reasons: lower cost, better exploitation of raw materials, elimination of waste, saving in labor, and achievement of better physical properties.

The world development of powder metallurgy is listed chronologically in the following table:

Chronological Development of Powder Metallurgy

Event	Date
Sintering of tungsten carbides with cobalt and other metals - Schröter	1922
First attempts to apply sintered diamond-metallic materials	1922
Industrial application of "Vidia" sintered carbides	1927
Application of pressed cores made of powder iron for high-frequency circuits	1927
Appearance of Skaupy's monograph, entitled Ceramics of Metals	1930
Basic works of Prof Dr Wl. Trzebiatowski	1934
Sintered magnetos, sintered metals and alloys for high vacuum	1934
Mass sinterings from iron and steel powders	1935 - 1939
Friction sintering	1939
Heat-resistant sinterings and ceramic metals	1940 - 1945

Professor Trzebiatowski occupied himself in 1934 with experiments on the properties of pressed, normally sintered, and hot-pressed powders of copper and gold, made tests for hardness, density, and electrical conductivity, and made X-ray observations of products pressed under various pressures and sintered under different temperatures.

Trzebiatowski applied for the first time pressures up to 30 tons per square centimeter while pressing powders, and he received for copper 97 to 98 percent of the density of the melted metal. The hardness amounted to 180 HB, which is very high in comparison with melted copper, the latter having 40-60 HB.

Sintering pressed shapes under very high pressure, Trzebiatowski noticed that their density was lowered, and he explained this by the presence of adsorbed gases on the grains.

The method of hot pressing was introduced into world literature as the Trzebiatowski Method. Tests on hot pressing of copper open up the possibility of obtaining metallic bodies having a very high degree of hardness and excellent electrical conductivity.

The first industrial enterprise concerned with this technology in Poland was the "Baildon" steel mill. This mill started the production of sintered carbides in 1936 under the trade name "Baildonit." The plants at Starachowice, using a Krupp license, began the production of sintered carbides in 1938 under the trade name "Distar." Before the war, the electrical industry pressed ferromagnetic cores and produced copper-graphite brushes.

The above-mentioned places (with the exception of one) were destroyed during the war. The production of sintered carbides, tungsten contacts, ferromagnetic cores and some metal powders was reactivated after the war. The production of these plants does not at present satisfy the demands of domestic consumption.

Research work has not been neglected. This work has already produced some results. Research on powder metallurgy is being conducted at the following places: Professor Trzebiatowski's research laboratory at the Wroclaw Polytechnic, the chairs of Professors Krupkowski and Loskiewicz at the Mining Academy, the Main Institute of Metallurgy at Gliwice, as well as industrial laboratories.

The production of sintered products is to be developed considerably and broadened under the Six-Year Plan.

The more important branches of powder metallurgy are to be activated, and the first prototypes of their products are to appear. These plans are described in a book by Engr E. Bryjak and Engr B. Zacharzewski entitled Metallurgia Proszkow w Planie Szescioletnim (Powder Metallurgy in the Six-Year Plan), written at the request of PKPG (Panstwowa Komisja Planowania Gospodarczego, State Economic Planning Commission).

Chronological Development of Polish Powder Metallury

Event	Date
Basic scientific works by Prof Dr Wl. Trzebiatowski	1934
Beginning of production of "Baildonit" sintered carbides	1936
Production of "Distar" sintered carbides	1938
Publication of book by Engr E. Bryjak, entitled Metal Ceramics	1946
Resumption of production of sintered carbides, tungsten contacts, compound carbon copper brushes, cores	1947 - 1949
Translation of book by R. Kieffer and W. Hotop, entitled Powder Metallurgy and Synthetic Sintered Products, State Technical Publishing House, Katowice	1951 (in preparation)
Powder Metallurgy in the Six Year Plan, by Engr E. Bryjak and Engr B. Zacharzewski, State Technical Publishing House, Warsaw	1951 (in preparation)

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